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Session NG19: Turbulent Fluid Dynamics

Broken ergodicity in ideal, homogeneous, incompressible turbulence

Lee Morin[1] and John Shebalin, NASA JSC

Terry Fu[2], Phu Nguyen[2] and Victor Shum[2], UH

We discuss the statistical mechanics of numerical models of ideal homogeneous, incompressible turbulence and their relevance for dissipative fluids and magnetofluids. These numerical models are based on Fourier series and the relevant statistical theory predicts that Fourier coefficients of fluid velocity and magnetic fields (if present) are zero-mean random variables. However, numerical simulations clearly show that certain coefficients have a non-zero mean value that can be very large compared to the associated standard deviation. We explain this phenomena in terms of `broken ergodicity', which is defined to occur when dynamical behavior does not match ensemble predictions on very long time-scales. We review the theoretical basis of broken ergodicity, apply it to 2-D and 3-D fluid and magnetohydrodynamic simulations of homogeneous turbulence, and show new results from simulations using GPU (graphical processing unit) computers.